

Fig. 2. Heart during supine LBNP and 60° HUT (N = 8).

baseline, minute 10 through -30 mmHg, presyncope, and during supine posttest baseline. Each bar represents a 3-minute mean.

Both hypotheses were successfully met. The HUT + LBNP can be used to reliably induce presyncope in men. However, the physiological data suggest that this device provides too strong a stimulus

for testing countermeasures when used with normotensive subjects.

Point of Contact: P. Cowings
(650) 604-5724
pcowings@mail.arc.nasa.gov

Ultrasonic Measurement of Intracranial Pressure Waveforms

Toshiaki Ueno, Richard E. Ballard, Lawrence M. Shuer, William T. Yost, John H. Cantrell, Alan R. Hargens

Intracranial pressure (ICP) dynamics are important for understanding adjustments to altered gravity. ICP may increase during microgravity due to a fluid shift to the head. As widely observed in clinical settings, elevated ICP causes headache, nausea, and projectile vomiting, which are similar to symptoms of the space adaptation syndrome. At levels over 20 millimeters mercury, ICP may compromise cerebral circulation. However, there are no experimental results to support the hypothesis that ICP is

actually altered during microgravity exposure, primarily because of the invasiveness of currently available techniques.

Ames has developed and refined an ultrasonic device that measures changes in intracranial distance noninvasively using a patented pulse phase locked loop (PPLL) technique. Although the skull is assumed to be rigid, many investigators report that the skull moves on the order of micrometers in association

with ICP pulsation resulting from variations in arterial pressure. The new ultrasonic device records ICP waveforms noninvasively from skull movements, enabling an evaluation of ICP dynamics by analyses of pulsatile components of ICP waveforms. Amplitudes of pulsatile components of ICP yield information on intracranial compliance, representing the magnitude of ICP change with a change in volume of any intracranial component (brain, blood, or cerebrospinal fluid). Clinically, it is important to monitor intracranial compliance because it represents the volume-buffering capacity of the intracranial tissues and fluid. In addition, because the intracranial volume-pressure curve is generally exponential, an inverse relationship exists between intracranial compliance and pressure. Thus, changes in mean ICP level can also be estimated from pulsatile components of ICP waveforms.

As previously reported, measurements by this ultrasonic device correlate well ($R^2 = 0.80$) with invasively measured ICP in cadavera. In this report, new data are obtained from patients under two different conditions. In the first measurement, waveforms of intracranial distance were collected in a patient who was undergoing a craniotomy. An

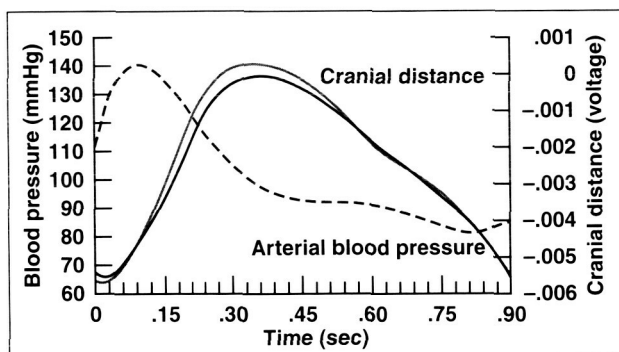


Fig. 1. Waveforms of the cranial distance and arterial blood pressure measured at the brachial artery are shown as solid lines and a dashed line, respectively. Waveforms of the intracranial distance were collected during two separate periods to demonstrate measurement reproducibility. Cranial distance is expressed as output voltages from the PPLL circuit.

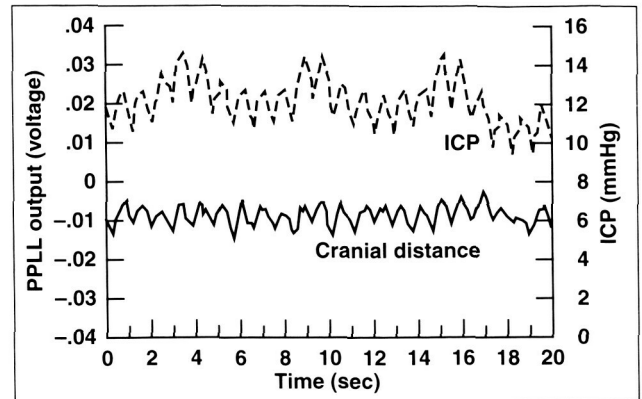


Fig. 2. Waveforms of the cranial distance and invasively measured ICP are shown as a solid line and a dashed line, respectively. Due to a low-frequency cut filter in the PPLL circuit, pulsatile components of respiratory origin are not detected in the cranial distance data.

ultrasonic transducer was placed directly on the surface of the patient's skull after a skin incision was made (the skull was intact at the time of measurement). The first figure shows that pulsatile changes in cranial distance were associated with a cardiac cycle. In the other measurement, changes were compared in cranial distance with invasively measured ICP in a head trauma patient. There was good correlation between the two measurements as shown in the second figure. Although there is still a possibility that cutaneous pulsation affects the measurement when a transducer is placed onto the skin, these results indicate that the technique is sensitive enough to measure pulsatile components of ICP waveforms noninvasively from skull movements in humans.

Point of Contact: T. Ueno/A. Hargens
(650) 604-5747/5746
tueno@mail.arc.nasa.gov
ahargens@mail.arc.nasa.gov